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CONCRETE PAVING BLOCKS: FACILITIES ENGINEERING APPLICATIONS PROGRAM (FEAP) DEMONSTRATION, FY89

by

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13. ABSTRACT *(Maximum 200 words)*
This report documents a field demonstration of the construction of a concrete block pavement at Aberdeen Proving Ground, MD. The block pavement was used to reconstruct a tank road intersection which was previously surfaced with unbound gravel and was suffering from continual maintenance problems.

A general description and history of concrete paving blocks are provided, as well as detailed discussions of the design and construction techniques used for the demonstration project. The current Corps of Engineers Guide Specification for the construction of concrete block pavements is provided in Appendix C.

By monitoring the performance of the block pavement, it was determined that the design and construction methods demonstrated by this study were valid. After 1 year of service, the block pavement continues to perform satisfactorily under daily tracked vehicle traffic. Concrete block pavements were proven as a viable pavement surfacing alternative for military tracked vehicles. Additional test sections and demonstration projects are proposed to validate the use of block pavements on airfields, port facilities, and motor pool areas.

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PREFACE

The US Army Engineering and Housing Support Center sponsored this concrete paving block demonstration as part of the O&MA Program, Facilities Engineering Application Program (FEAP), FY88, FY89 and FY90. The FEAP Technical Monitor was Mr. R. W. Williams; Mr. K. Gregg was the Technical Proponent group chairman. The project was coordinated by the Geotechnical Laboratory (GL), US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS. The demonstration project took place at Aberdeen Proving Ground, MD. It was designed in 1988, built in 1989, and monitored through 1990.

The project was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, GL, Messrs. H. H. Ulery, Jr., Chief, Pavement Systems Division (PSD), GL, and L. N. Godwin, Chief, Materials Research Center, PSD. This report was written under the direct supervision of Mr. T. W. Vollor, Acting Chief, Material Research and Construction Technology Branch, PSD. The WES FEAP Project Manager was Mr. R. H. Grau, PSD. Photographic support was provided by Mr. G. E. Dill of the Visual Production Center. Construction support was provided by Mr. P. G. Mijares, Jr., US Army Corps of Engineers, Baltimore District. The project Principal Investigator was Mr. G. L. Anderton who also wrote the report.

Commander and Director of WES during the conduct of the project and preparation of this report was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

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CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
inches	2.54	centimetres
miles per hour (international)	0.4476	metres per second
pounds (force)	4.448222	newtons
pounds (force) per square inch	6.894757	kilopascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
square feet	0.09290304	square metres
tons (mass)(2,000 pounds)	907.1847	kilograms

CONCRETE PAVING BLOCKS: FACILITIES ENGINEERING APPLICATIONS PROGRAM (FEAP) DEMONSTRATION, FY89

PART I: INTRODUCTION

Description

1. A concrete paving block is an accurately dimensioned combination of well-graded aggregates and hydrated portland cement which fits closely together with other paving blocks to form a pavement surface. The blocks are manufactured in a wide variety of shapes, some of which are shown in Figure 1. Generally, the blocks are about the size of a common brick with a thickness of 2-3/8 to 4 in.* and weigh about 9 to 12 lb each.

2. A thin, 1- to 2-in.-thick leveling course of sand is used under the blocks. The blocks are generally laid by hand on a sand layer. The blocks are then compacted with a manually operated vibratory plate compactor which seats the blocks in the sand layer, compacts the sand layer, and forces some sand into the joints between the blocks. Additional sand is then applied to the surface and swept into the joints between the blocks. More passes are made with the vibratory plate compactor to compact and wedge the sand into the joints. A base and subbase course under the leveling course provides structural support similar to that of a conventional flexible pavement. Figure 2 shows a generalized cross section of a block pavement. Many different patterns for laying blocks are possible, and several patterns are illustrated in Figure 3.

3. Concrete block pavements provide a low-maintenance, high-strength pavement surface that resists heavy, concentrated, or abrasive loads and chemical spills involving fuel, hydraulic fluid, and other materials. Their modular nature and potential for reuse allow easy removal and replacement for access to buried utilities or to correct settlement. A block pavement's unique characteristics (strength, abrasion resistance, flexible structure, and esthetics) make it applicable to many pavement uses, including military applications.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

History

4. The use of concrete blocks in pavements is recognized as the latest development in the long history of modular paving elements. The first record of stone paving goes back to 4000 B.C. in Assyria; clay brick paving was used in India in 3000 B.C. History tells us that the ancient Romans used blocks of hand-crafted stone in pavements throughout the Roman Empire. The Dutch have documented the use of natural stones and wood in urban streets throughout The Netherlands since the Middle Ages.

5. Before World War II, the traditional pavement surface course in many areas of Western Europe was the rectangular clay brick. After World War II, populations in Western Europe became more decentralized, and the demand for paving blocks grew enormously, especially since clay bricks were urgently required to rebuild buildings destroyed in the war. As a result of this demand, the concrete paving block was first introduced in The Netherlands in 1951 as an alternative to the traditional clay brick (Sharp and Armstrong 1985). Since most European countries had established histories of paving with stone blocks, the concrete block pavements were readily accepted, and their use has steadily increased in Europe since their introduction.

6. Concrete paving blocks were first produced in the United States in the 1960's using German production equipment and designs. At first, concrete paving blocks were used in the United States primarily for their aesthetic value in sidewalks, courtyards, driveways, and parking areas in expensive developments. Recently, paving blocks have been recognized for their potential in heavy-load pavement applications. Concrete block pavements have been used in low-speed, heavily-trafficked urban streets, port facility loading terminals, and, most recently, on airfield taxiways at the Dallas/ Fort Worth International Airport. The concrete paving block market is still developing in the United States and is expected to expand considerably in the near future.

7. Previous research at the US Army Engineer Waterways Experiment Station (WES) using heavy truck and tank traffic (Rollings 1983) has resulted in interim design guidelines for the Corps of Engineers. The design is similar to that for flexible pavement guidelines, except that the block and sand bedding layer is assumed to be equivalent to 6.5 in. of asphalt concrete

surfacing. This equivalency factor is based upon the standard 60-mm- or 80-mm-thick paving blocks.

Purpose of Report

8. This report documents the concrete paving block FEAP project at Aberdeen Proving Ground, MD, which was designed in FY88, constructed in FY89, and monitored in FY90. This report also provides general guidance for the design, construction, and use of concrete paving blocks as pavement surfacings.

PART II: DEMONSTRATION

Objective

9. The main objective of this demonstration is to familiarize the Directorate of Engineering and Housing (DEH) community with the latest concrete paving block technology. However, the project directly affected the installation where the demonstration was conducted by solving a local pavement problem with a solution designed to reduce significantly future maintenance costs.

Site Conditions

10. The demonstration site at Aberdeen Proving Ground, MD, was identified as an unsurfaced tank road intersection located on the outer rim of the Tank Retrieval Range Area. The intersection brought five range roads together near a tracked vehicle motor pool area. The traffic count for this intersection was estimated at 10 M-88 (56 ton) Tank Retrievers and 10 M-578 (30 ton) tracked vehicles per day. Approximately 12,000 sq ft of the existing gravel surfaced intersection was scheduled for reconstruction using the concrete paving blocks as the new pavement surfacing.

11. The existing subgrade was relatively weak (Design CBR 3) and when combined with heavy seasonal rains, the intersection required constant maintenance and regrading in order to remain functional. An economical surfacing of the intersection required a flexible pavement in order to withstand the settling conditions caused by the weak subgrade. Traditional flexible pavement surfacings, such as asphalt concrete, would not have withstood the abrasive action of the turning tracked vehicles. The combination of a soft subgrade and tracked vehicle traffic made the Aberdeen Proving Ground site a good candidate for the concrete paving block demonstration.

Design

12. The demonstration project at Aberdeen Proving Ground, MD, was designed by the US Army Corps of Engineers, Baltimore District, with the assistance of WES personnel, particularly on the concrete block pavement design. The details of the site evaluations and laboratory tests are contained in Appendix A.

13. The design of the concrete block pavement was based on the Corps of Engineers standard flexible pavement design as prescribed in Technical Manual TM 5-822-5/AFM 88-7, Chapter 3 (Headquarters, Departments of the Army and Air Force 1971). The thickness requirements of the base and subbase layers were computed based on the in-situ soil properties and equating the concrete block and sand bedding layers with 6.5 in. of asphalt concrete surfacing. Details of the pavement thickness design procedure are found in Appendix B.

14. The design results indicated that the total reconstructed pavement thickness, excluding recompacted subgrade, would be approximately 27 in. The pavement layers, from bottom to top, consisted of 12 in. of recompacted existing subgrade material, a geotextile for separation of subgrade and subbase, 19 in. of select-fill compacted in lifts as the subbase, 4 in. of crushed stone base course, 1/2 in. (final thickness) sand bedding layer, and 3.15-in.- (80 mm) thick paving block. The rectangular shaped paving block was specified since previous research had indicated that this block shape was appropriate for heavy-duty applications (Rollings 1983, Knapton 1984, and Kuipers 1984). A crosssection of the designed pavement layers is found in Appendix B.

Construction Techniques

15. Construction of the demonstration project at Aberdeen Proving Ground began in May 1989. At this time, the intersection was in relatively good condition as a result of an extended period of low rainfall (Figure 4). There were several areas of the intersection which had excessive amounts of fine aggregates and silts on the surface. This resulted from the tracked vehicles carrying these materials onto the gravel surface from the unsurfaced range roads leading to the intersection. When these areas became wet, the

effectiveness of the gravel surfacing was significantly reduced, and additional gravel was required to resurface these areas. This continuing cycle of required maintenance was to be eliminated by surfacing the intersection with concrete paving blocks.

16. The first step in the construction process was to erect silt fence barriers around the intersection (Figure 5) to prevent excessive silt runoff during the earthwork stage. Next, a total of 27 in. of the existing soil was removed (Figure 6), and the existing subgrade was compacted to meet the specified density requirements (Figure 7). The required density of the subgrade was at least 90 percent of the CE-55 maximum density. A geotextile was placed on top of the compacted subgrade (Figure 8), and a select-fill subbase material was spread and compacted over the geotextile in several lifts (Figures 9 and 10). The geotextile specified was a Mirafi 600X subgrade stabilization fabric, or equivalent. To complete the base and subbase construction, a 4-in. crushed stone base course was placed and compacted over the subbase (Figure 11). The required density of both the subbase and base course layers was 100 percent of the CE-55 maximum density.

17. After the final compaction and grade requirements for the base course were achieved, a cast-in-place concrete curb was built around the intersection area. A commercial slipform type curb machine was used for this process. The concrete curb was constructed at a 3-1/2-in. height differential from the surface of the base course to match the final thickness of the paving block and sand bedding layers. The curb would act as the required edge restraint to prevent the paving blocks from shoving under traffic.

18. Once the concrete curbs had sufficiently cured, construction of the paving block system began. A sand bedding layer was placed over an area of the compacted base estimated to equal to 1 day's coverage of paving blocks. The sand used for the bedding layer was clean and well graded, meeting the specification requirements listed in Appendix C. The sand was dumped and spread over this area (Figure 12) with the use of screeding pipes. The pipes were 1 in. outside diameter and were used along with a wooden screeding board to achieve the specified 1-in. initial depth (Figure 13). After screeding the 1-in. sand bedding layer on both sides of the screeding pipe, the pipe was carefully pulled and the resulting void in the sand layer was filled and screeded with a small piece of wood mounted on a broom handle.

19. The paving blocks were handlaid beginning at the center edge of one of the road entrances (Figure 14). A stringline was set up perpendicular to this curb edge to run from the start point through the center of the intersection. The stringline served as a reference point to begin and keep all block placement in perfect alignment. This technique was necessary since the concrete curbs surrounding the intersection area were curved and were in no particular alignment.

20. The herringbone pattern of block placement (described in Appendix B) was carefully established at the beginning of the block placement phase as the alignment of the entire block pavement depended on the initial blocks. The paving blocks were placed directly on the 1-in. sand bedding layer (Figure 15). The resulting height differential at the curb was 3/4 in. (Figure 16) to allow for 1/2-in. settlement of the sand bedding layer during compaction and an additional 1/4-in. estimated settlement of the underlying layers under traffic.

21. Near the end of each day's production, the newly laid paving blocks were compacted with several passes of a manually operated vibratory plate compactor (Figure 17). No compaction was allowed within 5 ft of the unfinished paving block edge in order to prevent the paving blocks from shoving outward. Once the paving blocks had been compacted, a fine-graded masonry sand was spread over the paving blocks (Figure 18) and broomed into the joints. This jointing sand had a considerably finer gradation (as described in Appendix C) than the bedding layer sand. Several passes of the vibratory plate compactor consolidated this jointing sand (Figure 19). The spreading and vibrating of the jointing sand was repeated several times until all paving block joints were filled.

22. The paving blocks were trimmed to the required dimensions and placed along the concrete curb edge restraint as the work progressed. Each block cut was measured by placing the block over the open area and marking the required cut line with chalk. A hand-operated splitting device was used to break the block along the cut line (Figure 20). This device produced a relatively clean and straight break. A slight angle was provided on every break to make the top surface approximately 1/4 in. longer (or wider) than the bottom surface. This chamfered edge helped the paving block to fit into the desired space much easier (Figure 21). Once a length of the pavement edge had

been trimmed in, the paving blocks were compacted and the joints filled in the same manner as previously described. Figures 22 and 23 show a finished edge before and after application of the jointing sand.

23. By the end of each working day, all areas of screeded bedding sand were covered by paving blocks to prevent disturbance of the sand bedding layer before block placement and compaction. The paving block installation for the entire 12,000 sq ft intersection was completed in approximately 16 working days. The paving block installation crew generally consisted of one person screeding sand and trimming in the edges, two people laying the paving blocks, and two people carrying the paving blocks from nearby pallet stacks to the block layers.

Initial Traffic Testing

24. The initial traffic testing of the block pavement took place on the same day the construction was completed. A 56-ton M-88 Tank Retriever (Figure 24), which was the heaviest vehicle scheduled to traffic the intersection, was used for the traffic tests. The M-88 first made several low-speed straight passes through the intersection. The tank retriever next performed high-speed breaking and acceleration maneuvers to check the block pavement's lateral stability. Since no damage occurred with the straight line maneuvers, the M-88 was allowed to make several 90-deg pivot steer turns. Again, no damage to the block pavement occurred. Finally, the M-88 was allowed to lock one track and perform several 360-deg pivot steer turns at high speed (Figure 25). This maneuver is thought to be the most severe in terms of surface abrasion from tracked vehicles. No damage to the block pavement was noticed; only scuff marks from the tracks' rubber pads were left on the pavement surface (Figure 26).

PART III: PERFORMANCE MONITORING

25. The paving block demonstration site was monitored during its first year of service to evaluate its field performance capabilities. Initial communications with Aberdeen Proving Ground personnel indicated that the concrete block pavement was performing exceptionally well with no reported block failures or rutting problems. The only maintenance performed during the first few months of use resulted from the tracked vehicles carrying a considerable amount of mud onto the block pavement from the training ranges. The mud was scraped off the pavement surface using a motor grader or dozer blade. Although this is not a recommended practice, no damage to the paving blocks was reported as a result of this maintenance procedure.

26. On 30 April 1990, WES personnel visited the demonstration site to observe the pavement under traffic and to determine the general condition of the concrete block pavement after 8 months of service. At this time, daily traffic was reported to average 12 passes per day of the M-88 Tank Retriever (Figure 27) in addition to several daily coverages from smaller tracked vehicles. No visual surface abrasion damage was noted. Straight-edge measurements were taken throughout the intersection area to determine if any significant settling or rutting had occurred (Figure 28). Only three isolated areas of slight wheel path rutting (< 3/8 in.) were found near the intersection entrance areas where the tracked vehicle traffic was noted to be the most channelized. The straight-edge measurements and visual observations indicated that the concrete block pavement had maintained its structural integrity during its initial service life.

27. WES personnel visited the demonstration site again on 22 August 1990 to observe the concrete block pavement. At this time, the pavement had been in service under daily traffic for approximately 1 year. Heavy rainfall before and during this site visit had caused a great deal of mud to be tracked onto the paving block intersection by the tracked vehicles (Figure 29). The heavily trafficked areas were covered with 6 to 8 in. of mud (approximately 60 percent of the total block pavement surface), and most of the remaining areas were covered with 1/2 to 1 in. of mud. Local personnel reported that these muddy conditions were not uncommon and did not seem to adversely affect the block pavement's performance. A few areas of paving blocks were visible

(Figure 30), and these areas indicated that the paving blocks were in good condition. Aberdeen Proving Ground personnel reported no major maintenance for this pavement during its first year of service and were very satisfied with the pavement's performance to date.

PART IV: ECONOMICS

28. The total cost of the paving block project at Aberdeen Proving Ground was $126,743. This cost included all subbase and base course work, the geotextile placed beneath the subbase, and all related incidentals and miscellaneous expenses. The cost of obtaining and placing the paving blocks, including all block and sand materials, labor, and equipment charges, was $51,431. This translates into a cost of about $4.29 per sq ft for the paving blocks on this job. The elimination of continual maintenance on this intersection (including regrading, drainage reconstruction, and other work) will result in long-term savings for the installation.

29. It was estimated that it would have cost approximately the same amount to build an asphalt concrete surfaced pavement structure capable of carrying the same traffic loads at this site. Building such an asphalt concrete pavement would not have been advisable, however, as the abrasive action of the turning tracked vehicles would have significantly shortened the service life of an asphalt concrete surface. Because of the relatively small surface area of the intersection, it was estimated that a portland cement concrete (PCC) pavement designed for the demonstration site would have cost between 10 and 30 percent more than the paving blocks for initial construction. Maintenance costs would likely have been high for a PCC pavement, resulting from costly crack repair, slab failures, and moisture damage. The concrete block pavement is expected to require virtually no maintenance throughout its 20-year design life.

30. In general terms, the cost of paving blocks vary considerably due to local differences in labor, material, block quality and size, and transportation costs (Rollings 1983). For large scale applications in the United States, block pavements are usually more expensive than conventional paving materials in terms of construction costs. Under some conditions, such as those of the demonstration site, the maintenance cost savings realized by using paving blocks instead of conventional paving materials give the paving block alternative the economic advantage.

31. The market for concrete block pavements is currently growing in the United States. More manufacturers are producing paving blocks to meet the increasing demands, thereby reducing freight costs in many areas. The number

of block paving contractors is also increasing, creating a more competitive market. It is anticipated that as the concrete paving block market grows in the United States, the relative cost of materials and construction for block pavements will decrease.

PART V: ADVANTAGES AND DISADVANTAGES

Advantages

32. There are many advantages in using concrete paving blocks under certain conditions. Weighing these advantages against the disadvantages of using concrete paving block is a much easier task when specific site conditions such as subgrade quality, material availability and cost, and traffic conditions are known. Although certain site conditions may create special benefits for using paving blocks, the following list comprises the major reasons for using paving blocks as a pavement surfacing. Concrete paving blocks:

- a. Provide a flexible pavement surface which is composed of durable, rigid materials.
- b. Provide a low-maintenance or zero-maintenance pavement surface.
- c. Can support large, concentrated loads and heavy, abrasive traffic.
- d. Can support heavy loads over relatively weak subgrades.
- e. Are comparatively high-quality pavement materials as the blocks ar. centrally manufactured and tested before going to the job site.
- f. Are resistant to environmental damage (e.g. freeze-thaw).
- g. Are resistant to damage from fuel and oil spillage.
- h. Allow for easy access to subsurface for utilities or subgrade repair.
- i. Are reusable (90 to 95 percent) after removing from an existing pavement surface.
- j. Negate traffic delays because of curing (in relation to PCC).
- k. Offer good skid resistance, wet or dry.
- l. Are aesthetically pleasing.

Disadvantages

33. There are some disadvantages in using concrete paving blocks that must be addressed when considering the block pavement alternative. Some of the potential disadvantages could be lessened in the future as research and market growth increase. The most prevalent disadvantages commonly attributed to the concrete paving block alternative are:

a. Sometimes higher initial cost, depending on job size, pavement thickness, location, etc.

b. Labor intensive construction process.

c. Rideability (smoothness) problems at high speeds (greater than 40 mph).

d. Water infiltration of underlying layers; therefore, no moisture sensitive base materials may be used. (This problem is usually only significant at the start of the pavement's service life before solidification of the jointing material.)

e. Lack of experienced designers, contractors, and block suppliers.

PART VI. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

34. The following conclusions are made, based on the findings of the demonstration project:

a. The 80 mm-thick rectangular concrete paving blocks laid in the herringbone pattern can withstand the heavy, abrasive loading conditions of military tracked vehicle traffic.

b. A concrete block pavement can support heavy loads over weak subgrades when constructed with appropriate base and subbase courses.

c. The current method of using the Corps of Engineers standard flexible pavement design with a 6.5-in. equivalent thickness ratio is a conservative but valid design method.

Recommendations

35. The following recommendations are made:

a. Concrete paving blocks should be considered as a pavement surfacing alternative when traffic demands and other site conditions make them economically feasible.

b. The concrete block pavement guide specification found in Appendix C should be used in future block pavement construction.

c. Additional test sections and demonstration projects are needed to develop other concrete paving block uses such as for airfields, port facilities, and motor-pool areas.

d. Additional materials research is needed in the areas of block strength requirements and joint sealants for stabilizing jointing sands.

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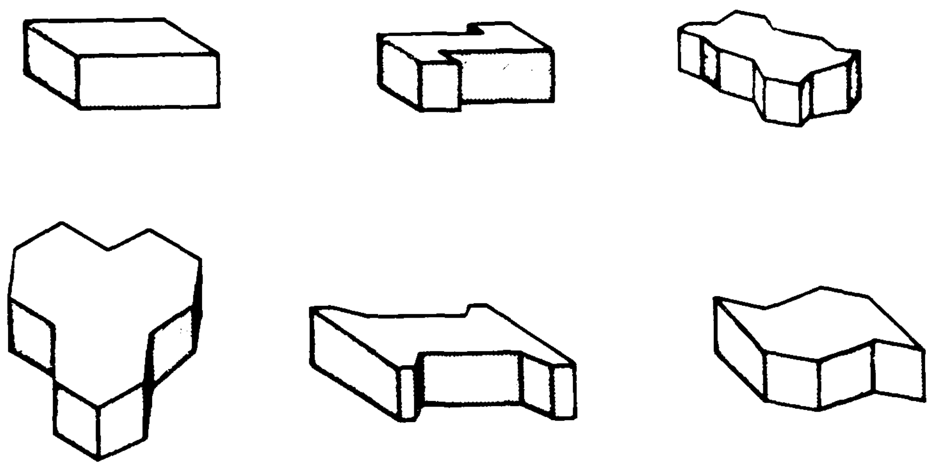


Figure 1. Examples of paving block shapes (after Rollings 1983)

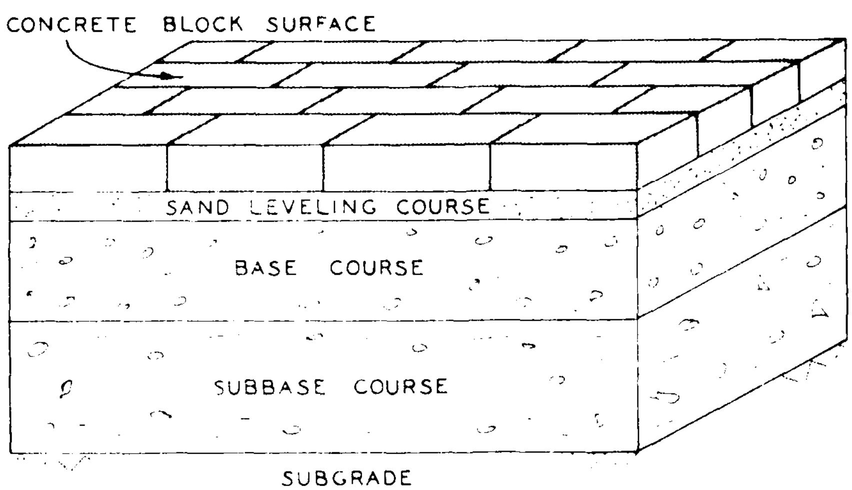
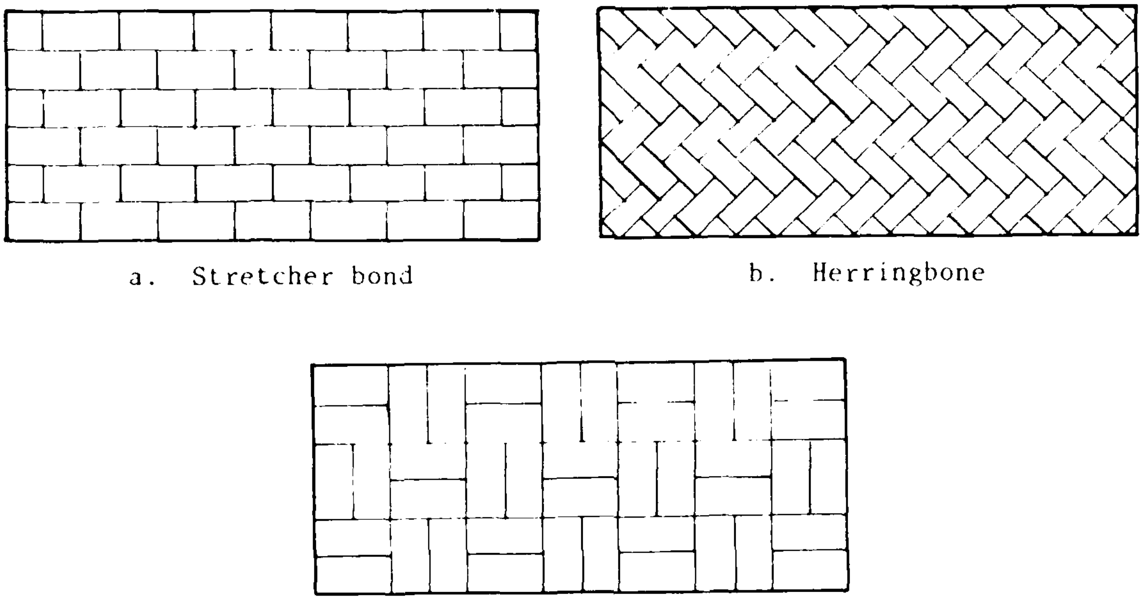


Figure 2. Typical cross section of block pavement (after Rollings 1983)



a. Stretcher bond

b. Herringbone

c. Parquet

Figure 3. Examples of common laying patterns (after Rollings 1983)

Figure 4. Gravel surfaced intersection area before reconstruction

Figure 5. Erecting silt fence barriers

Figure 6. Removing 27 in. of existing soil

Figure 7. Compacted subgrade

Figure 8. Geotextile on top of recompacted subgrade

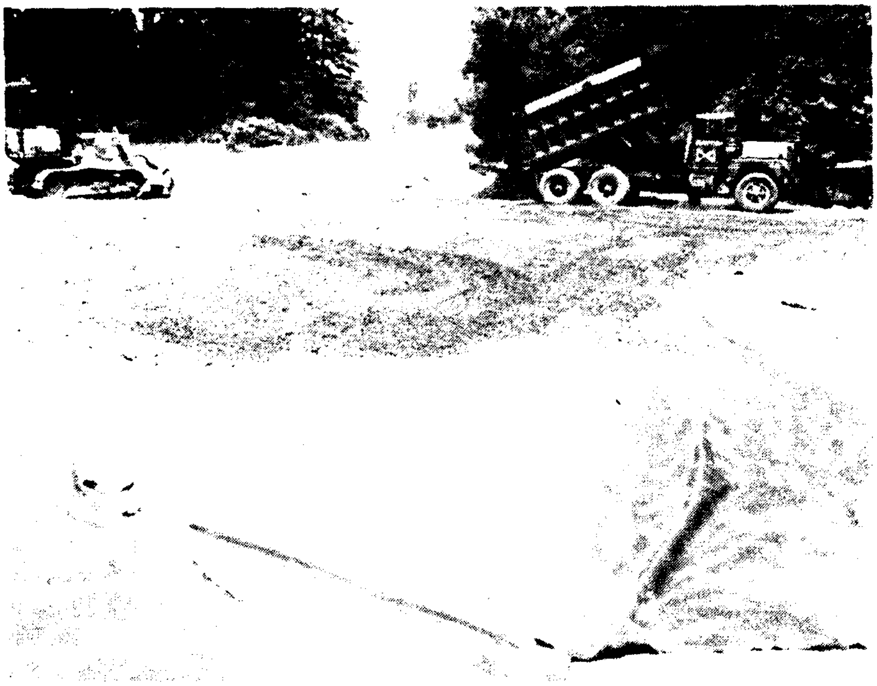


Figure 9. Select-fill subbase material being spread over geotextile

Figure 10. Recompacting select-fill subbase

Figure 11. A 4-in.-thick crushed stone base course

Figure 12. Spreading bedding sand

Figure 13. Screeding 1-in.-thick bedding sand layer

Figure 14. Hand placing concrete paving blocks

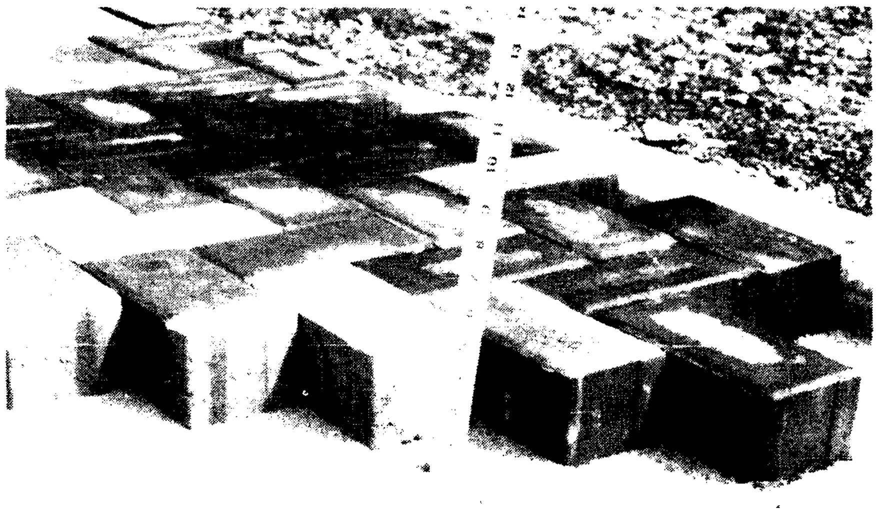


Figure 15. Paving blocks on top of 1-in.-thick sand bedding layer

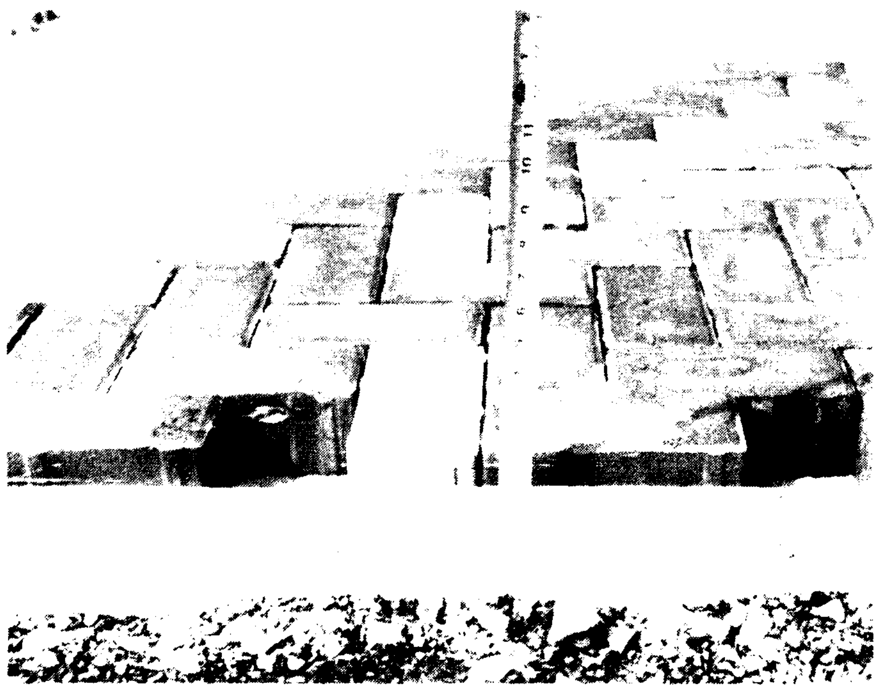


Figure 16. A 3/4-in.-height differential to allow for compaction and settlement

Figure 17. Initial compacting of paving blocks

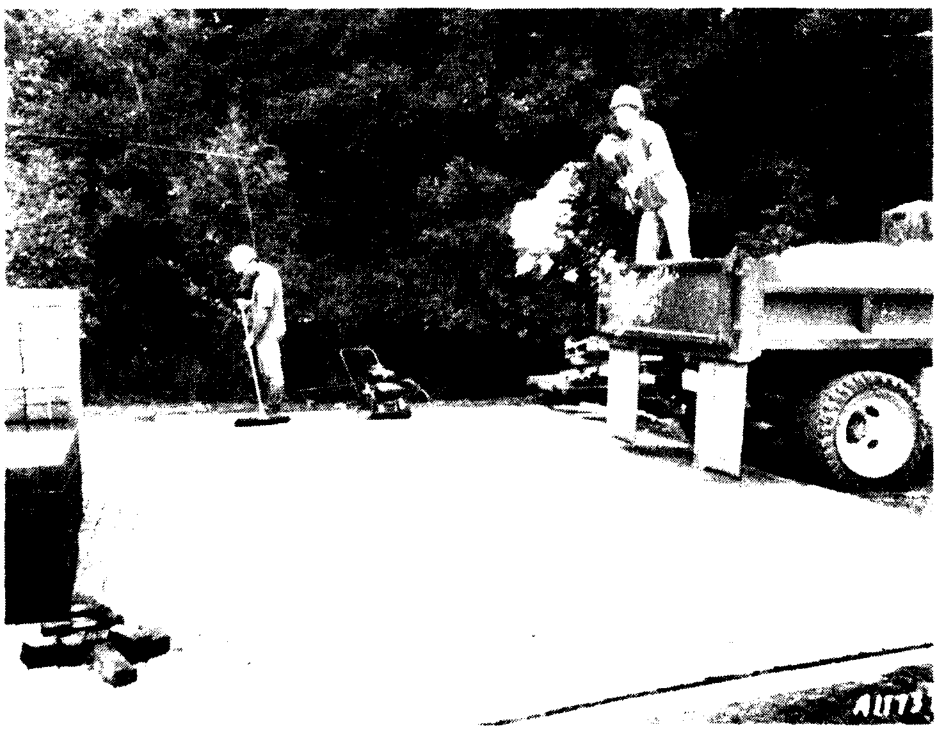


Figure 18. Spreading jointing sand over compacted paving blocks

Figure 19. Vibrating jointing sand into paving block joints

Figure 20. Cutting paving block with hand splitter

Figure 21. Trimming in pavement edge with cut block

Figure 22. Trimmed edge of block pavement without jointing sand

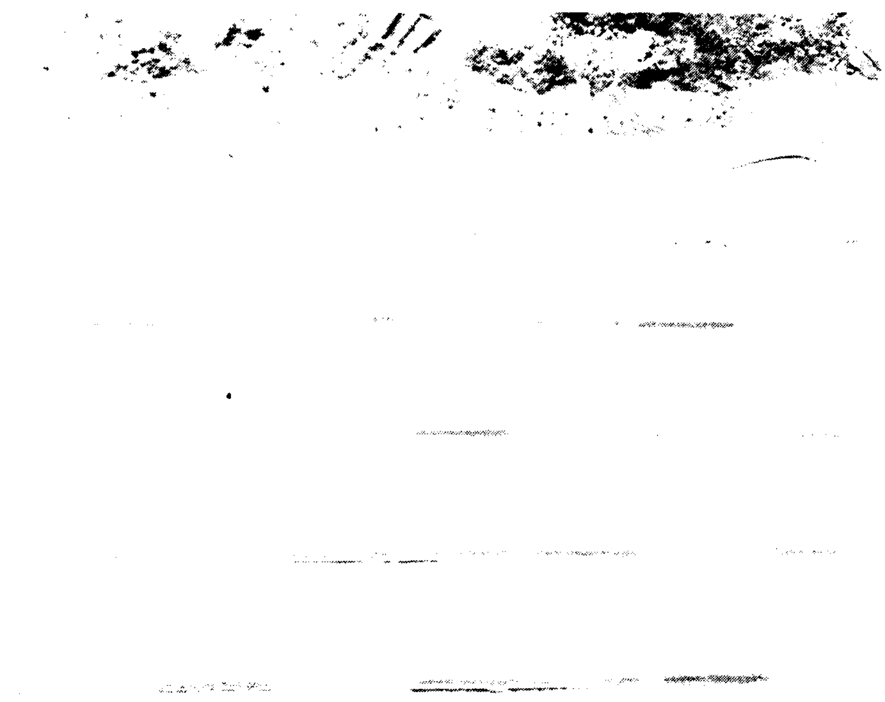


Figure 23. Trimmed edge of block pavement with jointing sand

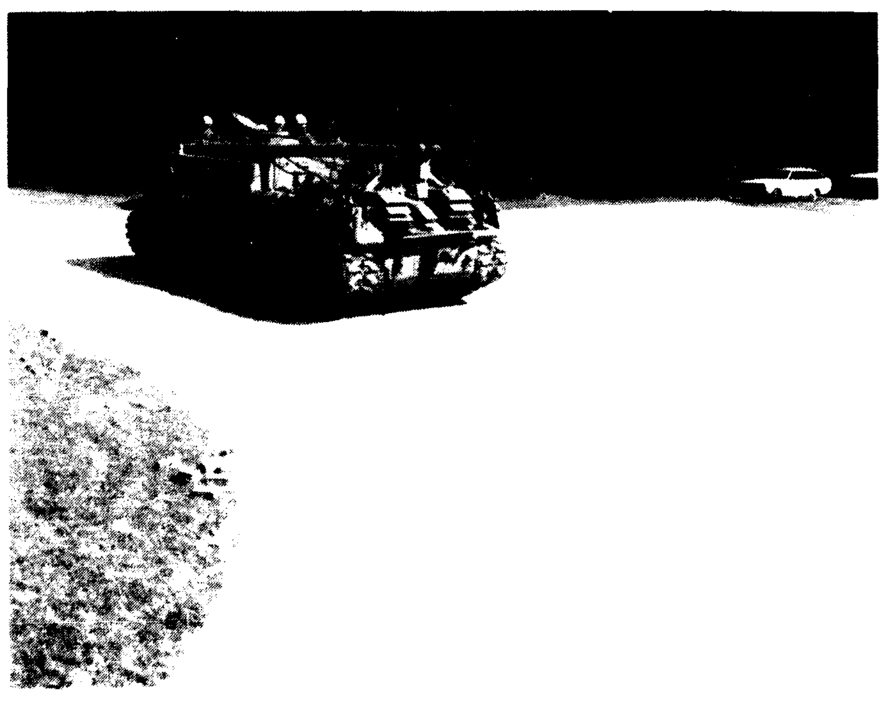


Figure 24. Initial traffic testing with M-88 Tank Retriever

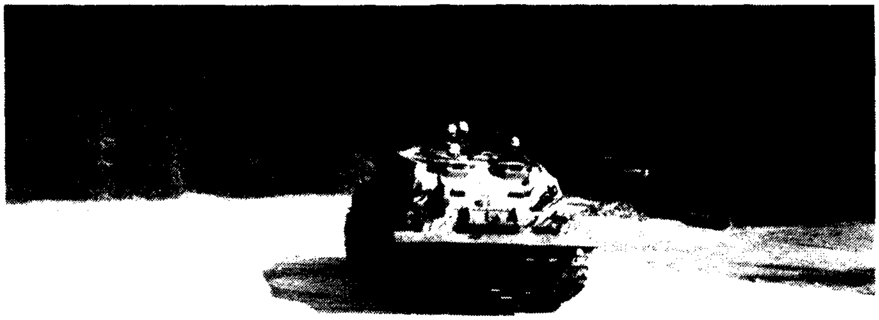


Figure 25. M-88 Tank Retriever performing 360-degree locked wheel turns

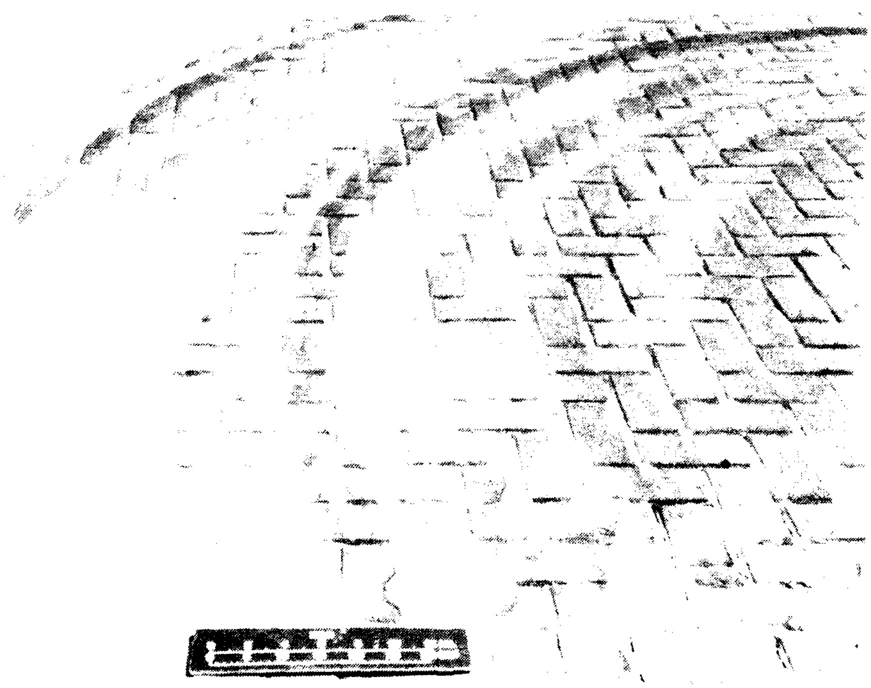


Figure 26. Rubber track marks left on top of undamaged paving block surface

Figure 27. M-88 Tank Retriever on 8-month old block pavement

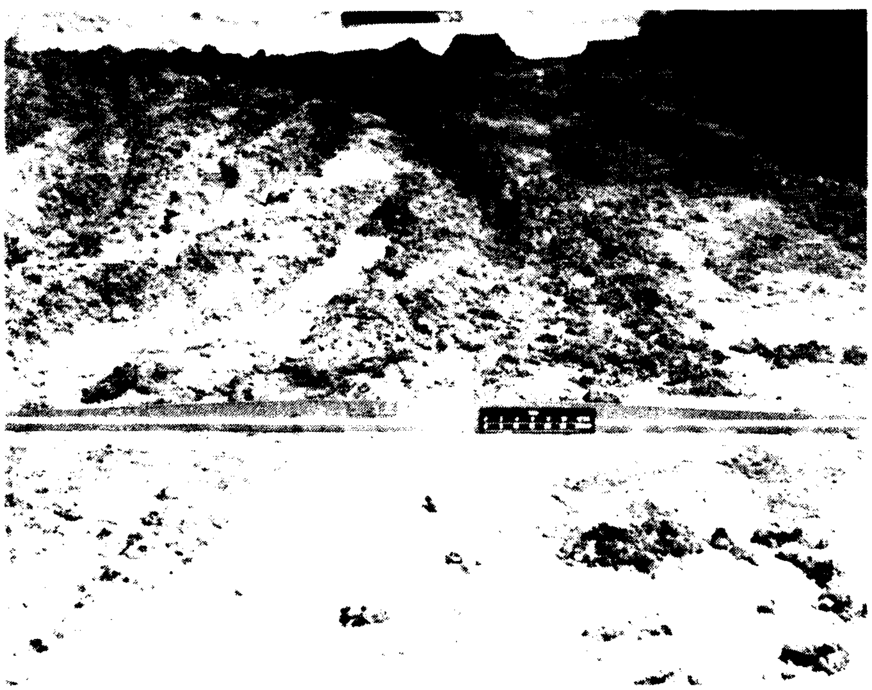


Figure 28. Straightedge measurements to check for pavement rutting (Note mud and water covered training area in background)

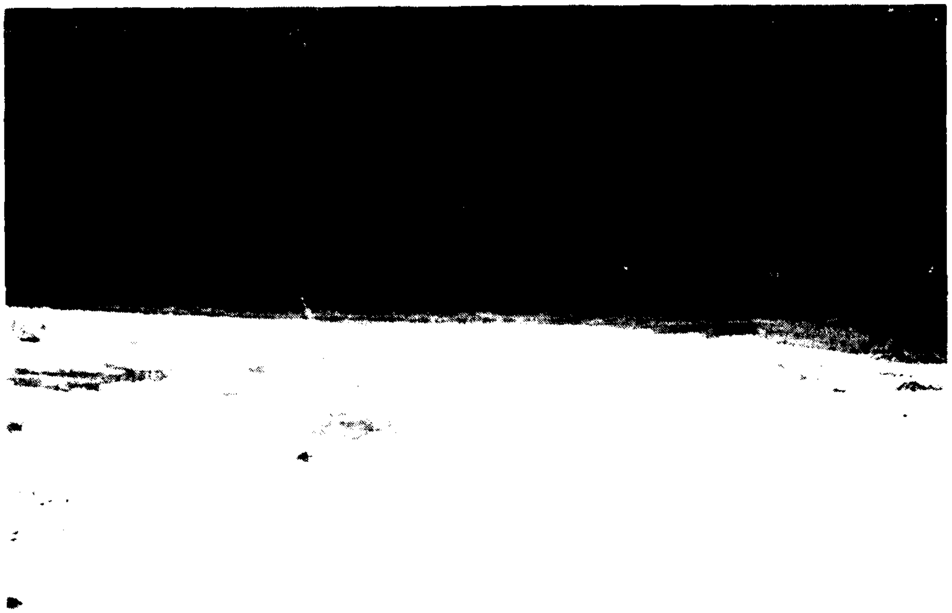


Figure 29. Mud covered block pavement after 1 year of service

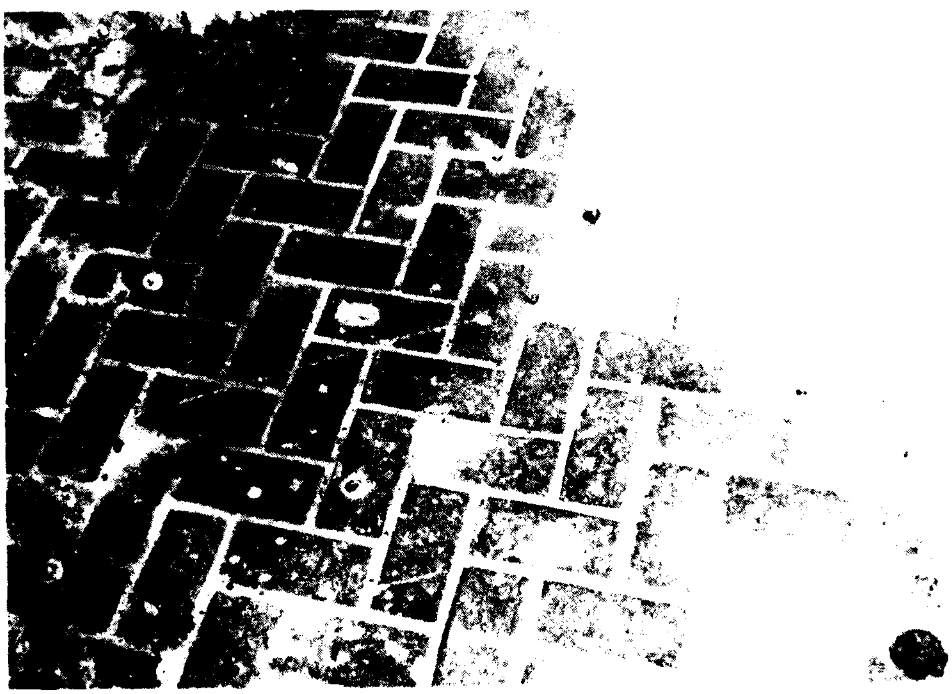


Figure 30. Close-up of block pavement after 1 year of service

APPENDIX A: CONCEPT DESIGN ANALYSIS

Concrete Block Pavements
Aberdeen Proving Ground, MD
Concept Design Analysis

1. Project Location and Scope. This project is partially funded by the US Army Engineer Waterways Experiment Station (WES) to demonstrate the construction of rectangular concrete block pavement and to gain data on its performance under tracked vehicles. The project involves upgrading approximately 10,000 sq ft of intersection and approximately 1,150 ft of roadway with concrete block pavement in the Aberdeen Area of Aberdeen Proving Ground. The site is located along the gravel surfaced portion of Belair Street and extends to its intersection with Convoy Road (Figure A1). The intersection is the critical portion of this project since it is used daily by tanks and other tracked vehicles to get to and from the adjacent tank retrieval ranges and tank trails. Although tracked vehicles are presently restricted from using Belair Street due to the maintenance costs on the gravel surface, the user intends on reopening this street to tracked vehicle traffic upon completion of this project.

2. Site Conditions.

a. Topography. The site is relatively flat with a slight crown across the gravel surfaced roadway and intersection. An existing wooded area borders the western edge of Belair Street and contains a stream which drains the site and runs roughly parallel with and approximately 200 ft west of the road (Figure A1). Some clearing and grubbing will be required along this western edge to install the new pavement. A tank retrieval range and a thin border of trees exist along the eastern edge of Belair Street. Existing wooded areas also border the intersection of Belair Street and Convoy Road. Reconstruction of the gravel surfaced intersection and the gravel portion of Belair Street will be required to provide proper drainage and an adequate pavement section. This decision was dictated by the unevenness of the existing gravel road surface, a need to match and extend the existing surface grades from the concrete portion of Belair Street, and an inadequate depth of existing gravelly material over a significant portion of the intersection and Belair Street. The excavated gravelly material will be separately stockpiled and reused in the proposed concrete block pavement section. Additional required base and subbase material will be obtained from off post sources.

b. Subsurface Conditions.

(1) Exploration. On 18 April 1988, nine auger borings were performed through the existing gravel surfacing on the road and intersection and extended down into the clay subgrade. The borings were 7.5 ft deep except for auger boring PB-3 which encountered auger refusal at 4 ft. Large bag samples were taken of the existing gravel surfacing material, and auger samples were taken of the clay subgrade.

(2) Laboratory Testing. All samples were visually classified in the laboratory. Mechanical analyses, Atterberg limits, and water contents were accomplished on representative samples of the different gravel surfacing materials and the clay subgrade.

(3) Soil Stratigraphy. The existing gravel surface of the road and intersection consist of a conglomeration of cobbles, sandy gravels, and gravelly sands of variable thickness (0.8 to 3.5 ft). These fill materials are underlain by the relatively soft natural sandy to silty clay subgrade.

(4) Ground water. No ground water problems are anticipated during construction since ground water was not encountered during the drilling for this project, and the ground water levels encountered at the adjacent Applied Instruction Facility (ground water elevation from 18.0 to 19.0 ft) are significantly below our proposed excavations. However, control of surface water drainage both within the project limits and from the adjacent sites will be important due to the relatively flat grades throughout this area.

3. Pavement Design.

a. General. The concrete block pavements have been designed to meet both strength and frost protection requirements in accordance with the latest Department of the Army criteria. The following references were used in the design of the pavements:

(1) TM-5-818-2, "Pavement Design for Seasonal Frost Conditions".

(2) TM-5-822-2, "General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas".

(3) TM-5-822-5, "Engineering and Design of Flexible Pavements for Roads, Streets, and Open Storage Areas".

(4) Technical Report GL-83-3, "Concrete Block Pavements", March 1983, US Army Engineer Waterways Experiment Station.

(5) Letter, DAEN-ECE-G, "Design of Gravel Surfaced Hardstands", 7 March 1985.

b. <u>Subgrade Design Parameters</u>. The subgrade is classified as an F-4 frost susceptibility group for frost design. Based on the California Bearing Ratio (CBR) test results from the adjacent Applied Instruction Facility (see Figure A1), and the relatively high moisture content of the onsite clays, a design subgrade CBR = 3 will be used in the design. Due to the relatively low strength of the subgrade soils, a subgrade stabilization fabric (Mirafi 600X or equal) will be specified to assist in construction and to reduce the required thickness of base/subbase course over these subgrade soils.

c. <u>Existing Gravel Surface Material Design Parameters</u>. A CBR range of 20 to 30 may be assumed for these materials with the final design value depending on the results of the Atterberg limit tests presently being performed. Although these materials have a significant percentage passing the No. 200 sieve (13 to 26 percent), they also have a significant portion retained on the No. 10 sieve (42 to 74 percent) and have performed satisfactorily over several seasons of heavy tracked vehicle traffic. The primary deficiency of these materials has been their inability to stand up to the churning action of the tracks, and the need for a subgrade separation medium to prevent the gravel from penetrating into the relatively low strength subgrade soils. Therefore, due to the monetary restrictions on this project, the excavated existing gravel surfacing material shall be reused as subbase course material in the proposed concrete block pavement section. Based on a concept design CBR = 20 for this material, and the 6.5 in. of equivalent asphalt surfacing and base course provided by the concrete block plus bedding sand (Reference: Technical Report GL-83-3), a 4-in. stone base course will be required over the existing gravel surfacing material to be used as subbase course material.

d. <u>Design Traffic</u>. The traffic consists of all types of wheeled and tracked vehicles. The controlling vehicle is the tracked M 88 Tank Retrieval Vehicle (56 tons) which has a frequency of 10 to 25 passes per day. Based on this category VII traffic, a design index of 10 shall be used for the concept pavement design.

e. <u>Pavement Section</u>. The concept pavement design calculations, the design pavement section, and the concrete block lay down pattern and installation notes are shown in Appendix B. Additional material and placement requirements on the concrete block pavement are contained in Appendix C.

4. Outline Specifications.

a. CEGS 02100, "Clearing and Grubbing".

b. NAB 02221, "Excavation, Trenching, and Backfilling for Utilities Systems".

c. NAB 02230, "Site Grading, and Excavation, Embankment, and Preparation of Subgrade for Roadways".

d. NAB 02241A, "Stone Base and Subbase Course" (to include filter and subgrade stabilization fabric).

e. NAB 02450, "Concrete Curb Edge Restraint" (to be edited from NAB 02450, "Concrete Sidewalks and Curbs and Gutters").

f. NAB 02518, "Concrete Block Pavements".

g. CEGS 03301, "Concrete for Building Construction" (minor requirements).

E. If there are any questions concerning this concept design analysis, please contact Mr. Stan Gembicki at (301) 962-4316.

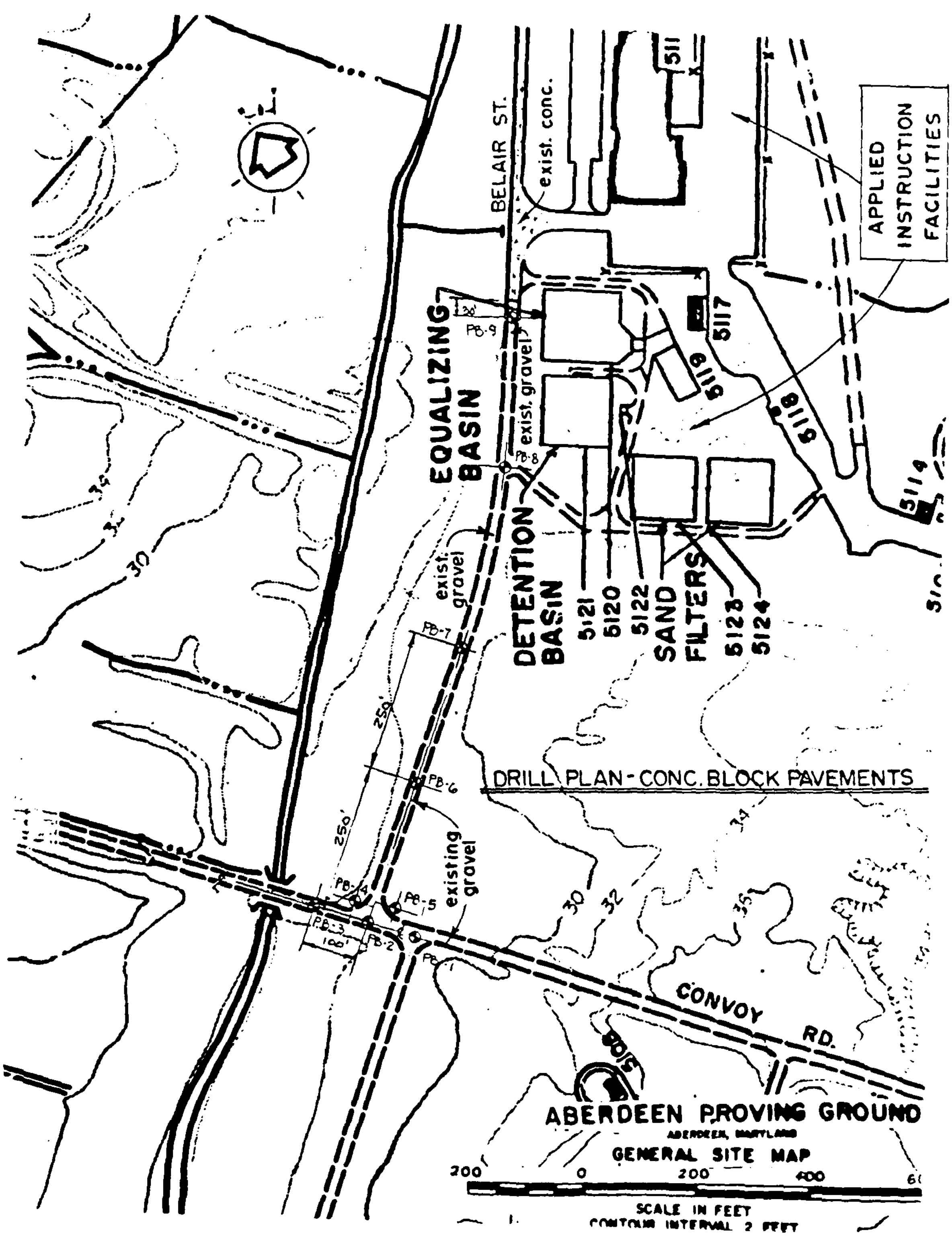


Figure A1. Project site plan

APPENDIX B: CONCRETE BLOCK PAVEMENT DESIGN

Flexible Pavement Design*

Project Concrete Block Pavements

Location Aberdeen Proving Ground, MD Date May 1988

1. Strength Design (Design Traffic-M88 (56 ton) tracked vehicle at 10-25/day)

   a. Road Class = - (Table 1 or 2 in TM 5-822-2)

   b. Traffic Category = VII (Para. 7b(4) or Table 3 in TM 5-822-5)

   c. Design Index = 10 (Table 4 or 5 in TM 5-822-5)

   d. CBR = 3 (Laboratory Test Results)(Based on test results, Adjacent Project: Applied Instruction Fac. and Soil (CL) Moisture on this job)

   e. Design Thickness = 35 in. (Fig. 3 in TM 5-822-5)

2. Frost Design

   a. Limited Subgrade Frost Penetration Method (LSFP)

      (1) Design Freezing Index = 360 (Fig. 3.2 in TM 5-818-2)

      (2) Base Course Water Content = (4 percent)

      (3) Dry Unit Weight of Base = (135 pcf)

      (4) Total Frost Penetration = a = 30 in. (Fig. 3.5 in TM 5-818-2)

      (5) Surface Course Thickness = p = 3.5 in. (Table 2 in TM 5-822-5)(3.1 in. concrete block unit plus approximately 0.5 in. bedding sand after seating and compaction on top of concrete block)

      (6) Base Thickness for Zero Frost Penetration into Subgrade C = a - p = 26.5 in.

      (7) Ratio of Subgrade Water Content to Base Water Content = r = (3)

      (8) Design Base Thickness = b = 15.5 in. (Fig. 4-1 in TM 5-818-2)

      (9) Subgrade Frost Penetration = s = 3.8 in. (Fig. 4-1 in TM 5-818-2)

* The use of this form does not preclude compliance with all requirements of TM 5-818-2, TM 5-822-2, and TM 5-822-5.

(10) Design Thickness = b + p = 15.5 in. + 3.5 in. = 19.0 in.

(11) Depth of Subgrade Preparation = 1/2(a)-(b+p) = 0 in.

NOTE: All quantities in parentheses are to be assumed if more exacting values are not known or are not available.

b. Reduce Subgrade Strength Method (RSS)

(1) Design Index = 10 (from 1c above)

(2) Soil Frost Group = F-4 (Table 2-1 in TM 5-818-2)

(3) Frost Area Soil Support Indice = 3.5 (Table 4-1 in TM 5-818-2)

(4) Design Thickness = 32 in. (Enter Fig. 3 in TM 5-822-5 with Frost Area Soil Support Indice as the abscissa)(see Fig. B1)

(5) Depth of Subgrade Preparation =
1/2(a)-RSS Design Thickness = 15 in. - 32 in. = 0 in.

The frost design is controlled by either 2a(10) or 2b(4), whichever is less, but in no case will the pavement section be less than that required by the strength design.

3. Design Pavement Summary

a. Design Method Summary

	Strength	LSFP	RSS
Design Thickness =	35 in. (Governs)	19 in.	32 in.

b. Reductions to Design Thickness

(1) Concrete Block + Bedding Sand = 6.5 in. of equivalent asphalt surfacing and base material (from Technical Report GL-83-3, "Concrete Block Pavements," March 1983, US Army Engineer Waterways Experiment Station.)

(2) Use of Subgrade Stabilization Geotextile = 6 in. reduction in base material (from Letter, DAEN-ECE-G, 7 March 1985, "Design of Gravel Surfaced Hardstands.")

c. Design Base/Subbase Thickness

35.0 in.	Controlling Strength Design
- 6.5 in.	Conc. Block and bedding sand
- 6.0 in.	Geotextile Stabilization
22.5 in.	Base/Subbase Material Required
(Use 23 in.)	

d. Design Pavement Section

3.1 in.	Concrete Block Paver
0.5 in.	Bedding Sand
4.0 in.	Stone Base Course
19.0 in.	Subbase Course
Geotextile Fabric (Mirafi 600X or equal)	

Design Index = 10

CBR	Thickness	CBR	Thickness
50	4 in.	8	18.5 in.
30	6.5 in.	6	22.5 in.
20	9 in.	4	29.5 in.
15	11.5 in.	3.5	32.0 in.
10	15.5 in.	3	35.0 in.

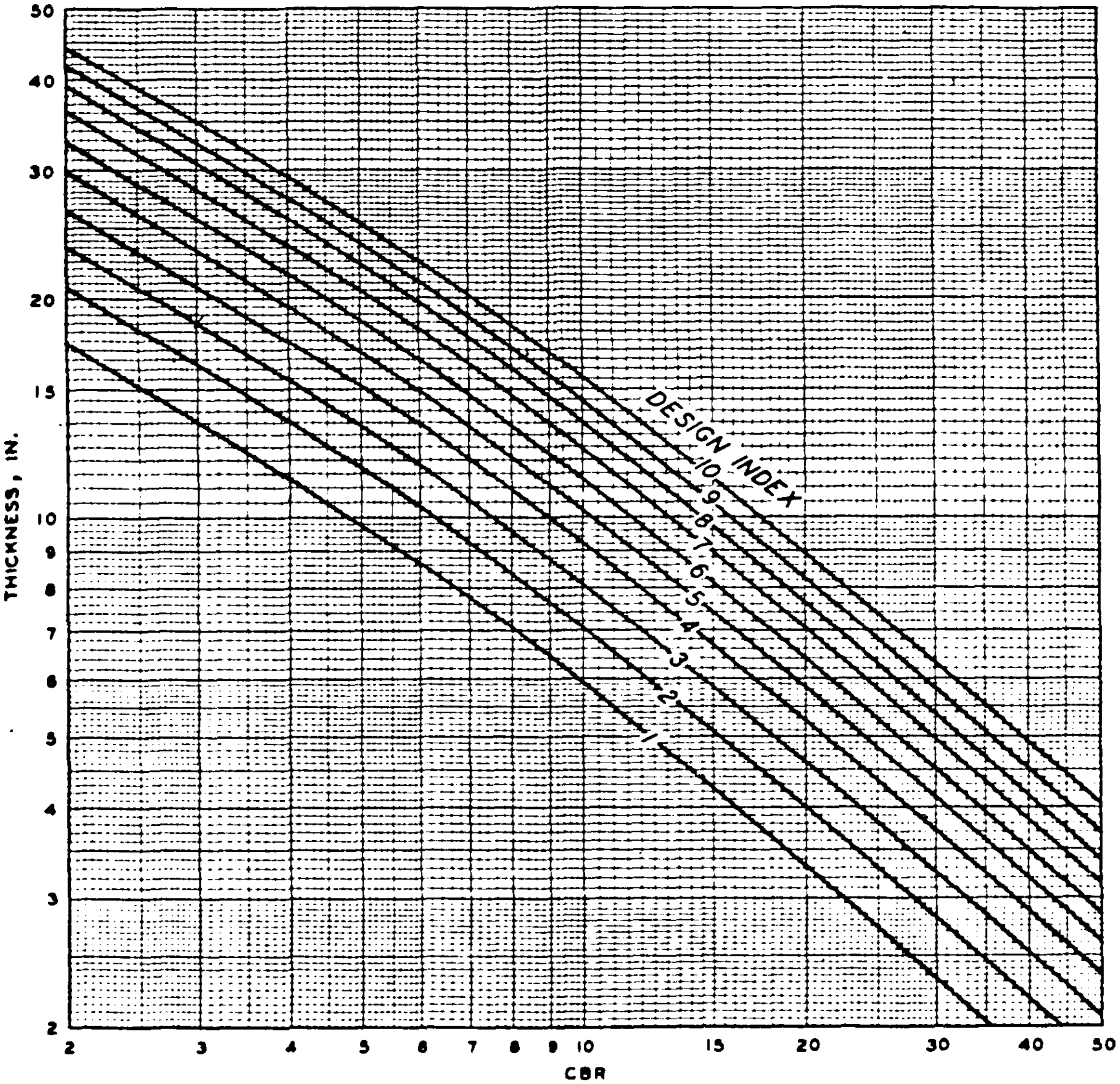


Figure B1. Thickness design requirements (Figure 3 from TM 5-822-5/AFM 88-7, Chap. 3)

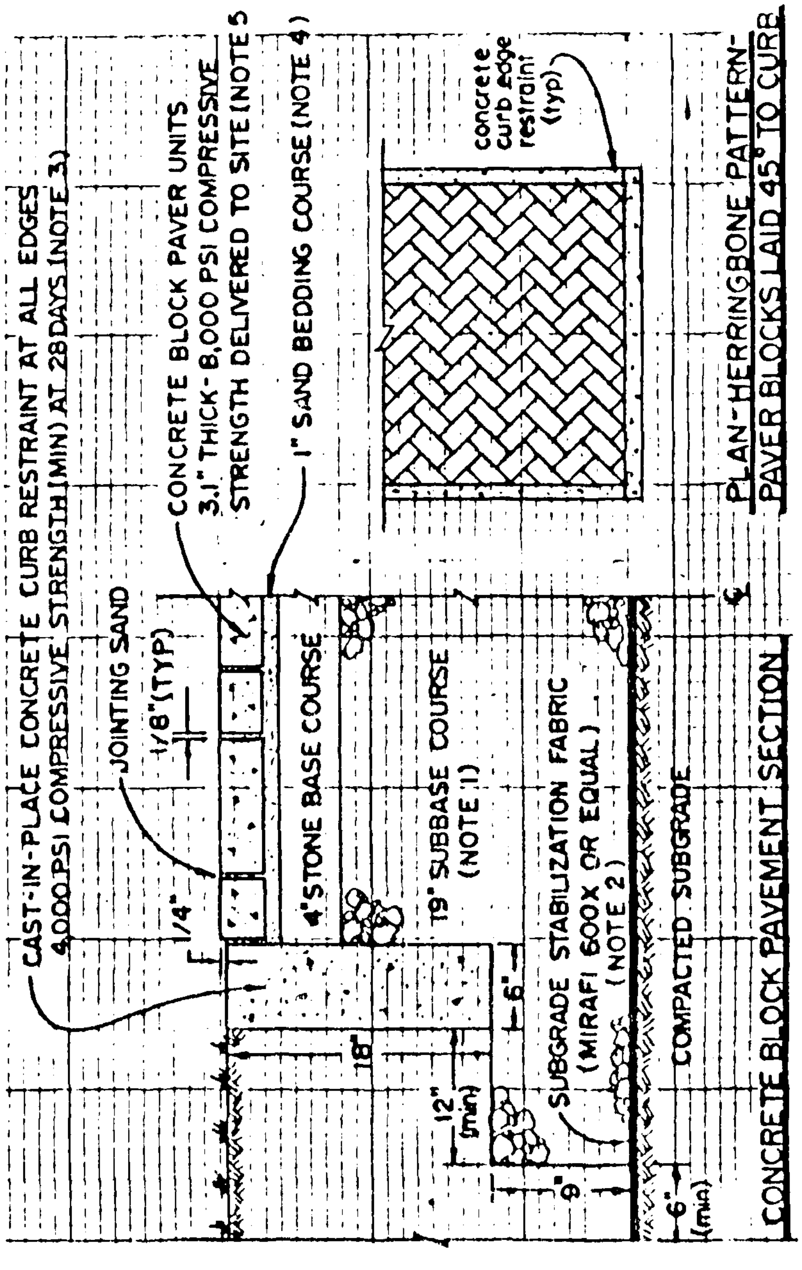


Figure B2. Concrete block pavement section and lay down pattern

Concrete Block Pavements - Installation Notes

1. Prior to starting all required excavations, remove any surface soil from the existing gravel road by backblading and sweeping. Remove and stockpile existing gravel road material separately from required soil subgrade excavation material. Reuse satisfactory stockpiled gravel road material for subbase course material in accordance with Specification Section 02241A. Subbase material will be required in addition to this stockpiled gravel road material. Required additional subbase material shall be obtained from off post borrow sources at the expense and responsibility of the contractor.

2. Refer to subgrade stabilization detail in Figure B2. Additional material and placement requirements for subgrade, subgrade stabilization fabric, and base and subbase are specified in Specification Sections 02230 and 02241A, respectively.

3. Install concrete curb edge restraint prior to placement of sand bedding course and concrete block paver units. The finished elevation of the concrete curb shall be set 1/4 in. below the top of the adjacent concrete blocks. Cut concrete blocks shall be used adjacent to the edge restraint as required to maintain the 1/8-in. joint. Filler fabric (Mirafi 140 or equal) shall be installed across all curb joints adjacent to jointing and bedding sand. Fabric shall overlap the joints by 6 in. (minimum) and extend 6 in. (minimum) below the bottom of the sand bedding course. Additional material and placement requirements for filter fabric and jointing and bedding sand are specified in Specification Sections 02241A and 02518, respectively.

4. Place and screed bedding sand to a depth of 1 in. $\pm$ 1/4 in. Do not compact or disturb sand prior to placement of concrete block paver units. Additional material and placement requirements for jointing and bedding sand are specified in Appendix C.

5. Brown rectangular concrete block paver units (3.1 by 3-7/8 by 7-7/8 in.) shall be hand placed in a herringbone pattern with blocks laid at a 45 deg angle to the edge restraints (refer to the illustrated herringbone pattern detail). Blocks shall be cast with a minimum of one 2-mm long vertical rib per side to assist in maintaining the 3-mm (1/8-in.) joint between blocks. Additional material and placement requirements for concrete block paver units are specified in Appendix C.

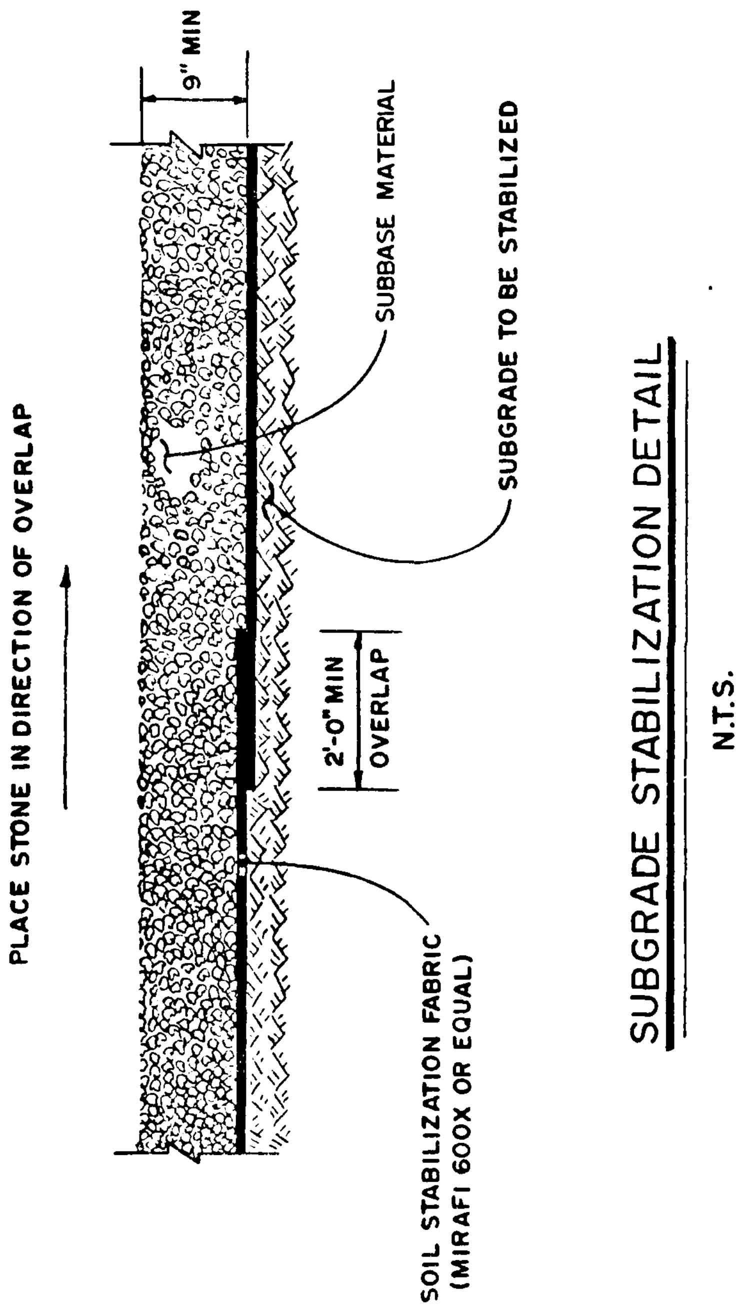


Figure B3. Subgrade stabilization detail

APPENDIX C: CONCRETE BLOCK PAVEMENT GUIDE SPECIFICATION

(September 1989)

****
DEPARTMENT OF THE ARMY CEGS-02518 (September 1989)
U.S. ARMY CORPS OF ENGINEERS

GUIDE SPECIFICATION FOR MILITARY CONSTRUCTION

****

SECTION 02518

CONCRETE BLOCK PAVEMENTS
9/89

****
NOTE: This guide specification covers the requirements for constructing a concrete block pavement. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.
****

PART 1 GENERAL

****
NOTE: See Additional Note A.
****

1.1 SUMMARY (Not Applicable)

****
NOTE: Paragraph "1.1 SUMMARY (Not Applicable)" is required in all CEGS in order to make CEGS compatible with guide specifications of other agencies within the SPECSINTACT System. However, this paragraph is not to be included in Corps of Engineers project specifications.
****

1.2 REFERENCES

****
NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

-ACI 301-	(1984) Structural Concrete for Building

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

-ASTM C 33-	(1982) Concrete Aggregates
-ASTM C 67-	(1987) Sampling and Testing Brick and Structural Clay Tile
-ASTM C 117-	(1987) Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
-ASTM C 131-	(1981; R 1987) Small-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
-ASTM C 136-	(1984; Rev. a) Sieve Analysis of Fine and Coarse Aggregates
-ASTM C 936-	(1982) Solid Concrete Interlocking Paving Units
-ASTM C 979-	(1982; R 1986) Pigments for Integrally Colored Concrete
-ASTM D 75-	(1987) Sampling Aggregates
-ASTM D 1760-	(1983) Pressure Treatment of Timber Products
-ASTM D 4318-	(1984) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
-ASTM E 11-	(1987) Wire-Cloth Sieves for Testing Purposes

1.3 SUBMITTALS

****
NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.
****

(September 1989)

The following shall be submitted in accordance with Section \=01300=\ "SUBMITTALS":

SD-50, Samples

The Contractor shall provide samples of paving blocks and the bedding and jointing sands in the quantities required under paragraph "TESTS, INSPECTIONS, AND VERIFICATIONS" and at times as directed by the Contracting Officer.

SD-70, Test Reports

The Contractor shall provide a written report within 7 calendar days after completion of the work to the Contracting Officer covering the testing required under paragraph "TESTS, INSPECTIONS AND VERIFICATIONS," for each lot.

1.4 PAYMENT

****

NOTE: Delete this paragraph in fixed price contracts.

****

1.4.1 General

Payments will constitute full compensation for all labor, equipment, tools, supplies, and incidentals necessary to complete the work.

1.4.2 Pavements

The blocks, cut blocks, bedding sand, and jointing sand will be paid per square foot of satisfactorily installed block pavement surface.

1.4.3 Edge Restraint

The edge restraint will be paid per lineal foot of satisfactorily installed edge restraint.

1.5 MAINTENANCE

****

NOTE: This paragraph will be included only if the project has aesthetic considerations where future maintenance must exactly match the color of the block.

****

At the completion of work the Contractor shall provide [_____] paving blocks matching those used in the project. These paving blocks will be delivered stacked on pallets.

(September 1989)

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Bedding and Jointing Sand

****
NOTE: See Additional Note B.
****

Two separate sand gradations shall be used for the bedding layer and in the block joints. Both sand gradations will consist of crushed sand, natural sand, or a combination of crushed and natural sand. Both sand gradations shall have a minimum L.A. Abrasion of 40 percent when tested in accordance with ASTM C 131. Both sand gradations shall be nonplastic when tested in accordance with ASTM D 4318 and shall be free of lumps, clay, vegetation, soft particles, sulphates, and other contaminants. The bedding and jointing sands shall conform to the following gradations, determined in accordance with ASTM C 136 and C 117.

	Percent Passing	
Sieve (ASTM E-11)	Bedding Sand	Jointing Sand
3/8 in.	100	100
No. 4	80-100	100
No. 8	60-90	95-100
No. 16	25-70	70-100
No. 30	10-35	40-75
No. 50	5-20	10-40
No. 100	0-10	2-25
No. 200	0-5	0-10

2.1.2 Concrete Paving Block

****
NOTE: Color and shape of block may be specified. Check local availability of specific colors or shapes before specifying. Organic pigments should not be used, since they are unstable in the alkaline concrete environment and subject to weathering. Shape is generally rectangular or interlocking.
****

The concrete paving block shall conform to ASTM C 936, and shall be [_____] thick, [_____] in color, and [_____] in shape. Color shall conform to ASTM C 979.

2.1.3 Edge Restraint

2.1.3.1 Treated Wood

****
NOTE: Treated wood edge restraint is only acceptable for walkways and residential driveways. If treated wood is selected for edge restraint, then ASTM D 1760 (1983) "Standard Specification for Pressure Treatment of Timber Products" should be added. Delete this paragraph when this option is not retained.
****

The edge restraint shall be wood treated in accordance with ASTM D 1760 and of dimensions shown on the plans.

2.1.3.2 Precast Concrete

****
NOTE: Minimum compressive strength of precast concrete should be 3,000 pounds per square inch unless analysis requires some other value. Entrained air content should be 6 percent ± 1-1/2 percent in areas where freezing and thawing coverage is a design consideration. Delete this paragraph when this option is not retained.
****

The edge restraint shall be precast portland cement concrete elements with the dimensions shown on the plans. The precast concrete shall have a compressive strength of not less than [_____] at 28 days and an entrained air content of not less than [_____].

2.1.3.3 Cast-in-Place Concrete

****
NOTE: Minimum compressive strength of cast-in-place concrete should be 3,000 pounds per square inch unless analysis requires some other value. Entrained air content should be 6 percent ± 1-1/2 percent in areas where freezing and thawing coverage is a design consideration. Delete this paragraph when this option is not retained.
****

The edge restraint shall be portland cement concrete placed with the dimensions shown in the plans. Concrete shall have a compressive strength of not less than [_____] at 28 days and an entrained air content of not less than [_____]. Concrete shall conform with the requirements of ACI 301.

2.2 TESTS, INSPECTIONS AND VERIFICATIONS

2.2.1 Concrete Paving Block

****

NOTE: See Additional Note C.

****

The Contractor shall provide a sample of five paving blocks prior to the start of the work for the Contracting Officer's approval of the color and shape to be used in the project. Also, the Contractor shall collect a representative sample of not less than 15 blocks as directed by the Contracting Officer, from each lot of 20,000 concrete paving blocks or fraction thereof. Two paving blocks from each sample will be delivered to the Contracting Officer. The Contractor shall conduct the tests prescribed by ASTM C 936 and the following tests under the guidance of the Contracting Officer on the remaining 13 blocks of each sample from each lot.

2.2.1.1 Freezing and Thawing

****

NOTE: The freezing and thawing test may be waived for jobs of less than 10,000 square feet or for climates not subject to freezing and thawing.

****

Resistance to freezing and thawing will be determined in accordance with Section 8 of ASTM C 67 for five blocks. The blocks shall have no breakage and no more than 1.0 percent loss of any individual unit in dry weight when subjected to 50 cycles of freezing and thawing.

2.2.1.2 Dimensional Tolerance

The length and width of each block in the sample will not vary from any other block in this or any other lot sample by more than 1/8 inch. Thickness of any block in the sample will not vary by more than 1/8 inch from the specified block thickness.

2.2.1.3 Retest

The Contractor will notify the Contracting Officer if any blocks fail to meet the specified requirements. In case the shipment fails to conform to the specified requirements, the Contractor may sort it, and new specimens shall be selected by the Contractor from the retained lot for retesting, as directed by the Contracting Officer. All concrete paving block retests shall be performed at the expense of the Contractor. In case the second set of specimens fail to conform to the test requirements, the entire lot shall be rejected.

2.2.2 Sand

2.2.2.1 Sample

The Contractor shall obtain a representative sample in accordance with ASTM D 75 from each 100 cubic yard of sand to be used in the project.

2.2.2.2 Gradation

The Contractor shall determine the gradation of the sand in accordance with the requirements of paragraph "MATERIALS".

2.2.2.3 Test Results and Retest

If the sand fails to meet the requirements of paragraph "MATERIALS", the Contractor may take another sample and retest it at his expense. If this retest fails or if no second test is taken, the sand is rejected by the Government and shall be removed from the job site.

PART 3 EXECUTION

****
NOTE: See Additional Note D.
****

3.1 PREPARATION

3.1.1 Edge Restraint

The edge restraint shall be placed as shown in the drawings and will be installed prior to placement of the blocks.

3.1.2 Sand Bedding Layer

The bedding sand shall be spread evenly over the area to be paved and shall be screeded to an uncompacted average thickness of 1-1/4 inch with a tolerance of ± 1/4 inches. This bedding sand will not be used to fill low areas in the base. The sand shall be left uncompacted and will not be disturbed by any pedestrian or vehicle construction traffic.

3.2 BLOCK PLACEMENT

****
NOTE: Paving block to be subject to vehicular traffic should be placed in herringbone pattern, and this pattern can be specified here.
****

(September 1989)

The paving block shall be placed by hand or machine in the indicated pattern. Placement of paving block will start from a corner or straight edge and proceed forward over the undisturbed sand bedding layer. The joints excluding any chamfer between paving blocks shall be not less than 1/16 inch or more than 1/4 inch in width. The paving blocks will be placed so that after seating as described in paragraph 3.2.2 the block surface will be flush or up to 1/4 inch above the edge restraint.

3.2.1 Unfilled Gaps

Any gaps between paving blocks and any edge restraint, drainage structures, or other members that cannot be filled with a whole block will be filled with a paving block cut to fit the gap. Cutting will be done with a hydraulic splitter, a masonry saw, or other device that will accurately leave a clean, vertical face without spalling. Any gap between the block and adjoining edge restraint or structure greater than 1/4 inch shall be rejected.

3.2.2 Seating Blocks

The blocks shall be seated in the bedding sand by compacting them with a minimum of three passes of a vibratory plate compactor.

3.2.3 Jointing Sand

The jointing sand shall be swept into joints and vibrated with a vibratory plate or vibratory roller compactor. This process will be continued until sweeping and vibrating have filled all joints with sand and further vibration cannot force additional sand into the joints. The coarser particles of the sand will not enter the joints and will remain on the surface. These particles and any excess sand will be swept off the pavement.

3.2.4 Timing of Operations

Seating of blocks and placement of jointing sand can be done concurrently with block placement. However, seating of blocks and placement of jointing sand will not be done within 5 feet of any unfinished edge of the block pavement that is not supported by the edge restraint.

3.2.5 Final Rolling

****
NOTE: This paragraph can be deleted for light load pavements such as driveways or pedestrian walkways.
****

The final finished paving block surface will be rolled with four passes of a vibratory or pneumatic roller with a static weight of not less than 10,000 pounds.

3.2.6 Construction Traffic

Construction traffic shall not be allowed on the paving block surface until the jointing sand has been placed and vibrated into the joints.

3.3 CLEANUP

The Contractor shall sweep the entire pavement surface and remove all excess sand, blocks and debris from the project area.

3.4 SMOOTHNESS AND GRADE TOLERANCES

3.4.1 Smoothness

No portion of the finished pavement surface will deviate by more than 3/8 inch from a 10-foot-long metal straightedge placed on the pavement surface.

3.4.2 Block Height

The finished block surface will be either flush or up to 1/4 inch higher than all edge restraints or drainage structures.

3.4.3 Grade

The finished pavement will be within 0.04 feet of planned grade shown on the plans.

3.4.4 Remedial Action

Any area not meeting the smoothness, block height, or grade tolerance will be taken up, adjustments made, and the blocks relaid.

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ADDITIONAL NOTES

NOTE A: For additional information on the use of all CEGS, see CEGS-00000 "CEGS General Notes."

NOTE B: If the pavement is to be subjected to Design Index traffic of 8 or higher, both the bedding and jointing sands shall consist of 100 percent crushed sand if it is available in the construction locale. For block pavements to be used for walkway, driveway, storage area, parking area, or subject to traffic Design Indexes of 1 or 2, the bedding sand gradation can be changed to the fine aggregate gradation in ASTM C 33 with the additional requirement of 0-10 percent passing the No. 200 sieve.

NOTE C: Sampling of paving blocks prior to the start of the work for the purposes of verifying the color and shape of the blocks will only be required when these considerations are critical to the project aesthetics. For jobs of less than 10,000 square feet or for pavements not to be exposed to vehicular traffic, a manufacturer's certificate which certifies that the paving blocks meet the requirements of ASTM C 936 can be accepted in lieu of sampling and testing the blocks of each lot.

NOTE D: The base course for the block pavement must be a dense graded or bound material to avoid loss of the sands from the bedding layer. It must also be properly graded and leveled. A smoothness of no more than 3/8 inch deviation from a 10-foot straight edge is needed. The project specification for the pavement base course should be checked to ensure these requirements are met.

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-- End of Section --